NUCLEAR ENERGY RESEARCH INITIATIVE

Ni-Si Alloys for the S-I Reactor-Hydrogen Production Process Interface

PI: Joseph W. Newkirk, University of Missouri

Collaborators: Idaho National Laboratory

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Project Description

The goal of this project is to develop materials suitable for use in the sulfuric acid decomposition loop of the sulfur-iodine thermochemical cycle for nuclear hydrogen production. Materials must possess both acceptable corrosion resistance and sufficient ductility for component fabrication and avoidance of catastrophic failure. Nickel-silicon intermetallics show promise for such critical applications as the sulfuric acid vaporizer, vapor superheater, and the decomposer. Past work indicates that adding minor alloying elements to Ni_3Si provides significant ductility at room temperature (7-10 percent elongation at failure)—this is a unique property for high silicon materials, which are usually brittle. Ni_3Si can also be easily joined by traditional methods such as welding. In addition, preliminary studies indicate that it has excellent corrosion resistance.

In this work, Ni_3Si will undergo further development to maximize ductility and corrosion resistance while reducing cost. The effects of adding elements such as niobium, boron, and iron will be analyzed. Microalloying may also be used to improve resistance to expected corrosive impurities in the sulfuric acid processing stream, such as iodine. Finally, the extent to which iron can be substituted for nickel in Ni_3Si without adversely affecting ductility or corrosion resistance will be studied.

The mechanical properties of these new materials will be documented over a range of temperatures and strain rates. The results will be used to improve material properties and microstructure. As a final test, corrosion-resistant materials will be subjected to flowing H_2SO_4 at temperatures and pressures comparable to the actual sulfuric acid processing loop (120-400°C at <10,000 psi) in order to measure corrosion rates. Various fabrication techniques will also be exercised by forming prototype plates, pipes, and forgings.

Workscope

The research will be divided into four areas:

- Materials development for ductility and corrosion resistance
- Thermal and mechanical property characterization
- Corrosion resistance in sulfuric acid
- Fabrication issues